1

The environment

'Believe me, Sire, these countries far surpass all the rest of the world in beauty.'

Columbus to King Ferdinand, from Cuba, 1492

'Out to sea, far west of Spain,
Lies the land men call Cockaygne.
No land that under heaven is
For wealth and beauty comes near this.'

Fourteenth-century English poem

To the small party of Europeans who travelled to the New World in the three ships commanded by Columbus in 1492, the physical attractiveness and plenitude of the shores on which they landed, and of their hinterlands, as well as their beneficent climate, all presented a most favourable impression, and one which for a while virtually overwhelmed them. All the islands which they visited, from the Bahamas to Española and Cuba, were described as being green and fertile, and blest with a trade wind climate, a climate of 'perpetual spring', which was at the same time both warmer and gentler than that of the south of Spain from whence they came. The lushness of the vegetation, its scents which were carried many miles out to sea, and the profligacy of its fruits, were all recorded with enthusiasm, along with the rich diversity of bird life, including flocks of parrots which blotted out the sun. To Columbus, the islands were indeed 'roses of the sea'[1]. Of Española, the island along whose coast he spent most time during the first voyage, he suggested that 'the best lands of Castile cannot be compared as to beauty or fertility with these ... nor did the plain of Cordoba equal them, the difference as great as between night and day' (Iglesia, 1944); as an expression of his esteem, one valley along that coast, that of Trois Rivières, was renamed the Valle del Paraiso. The coast of Cuba was described as being 'most beautiful', and the Bahamanian group of islands had luxuriant pristine vegetation down to the sea. Similarly positive narratives were recorded on later voyages about other Caribbean territories, from the high

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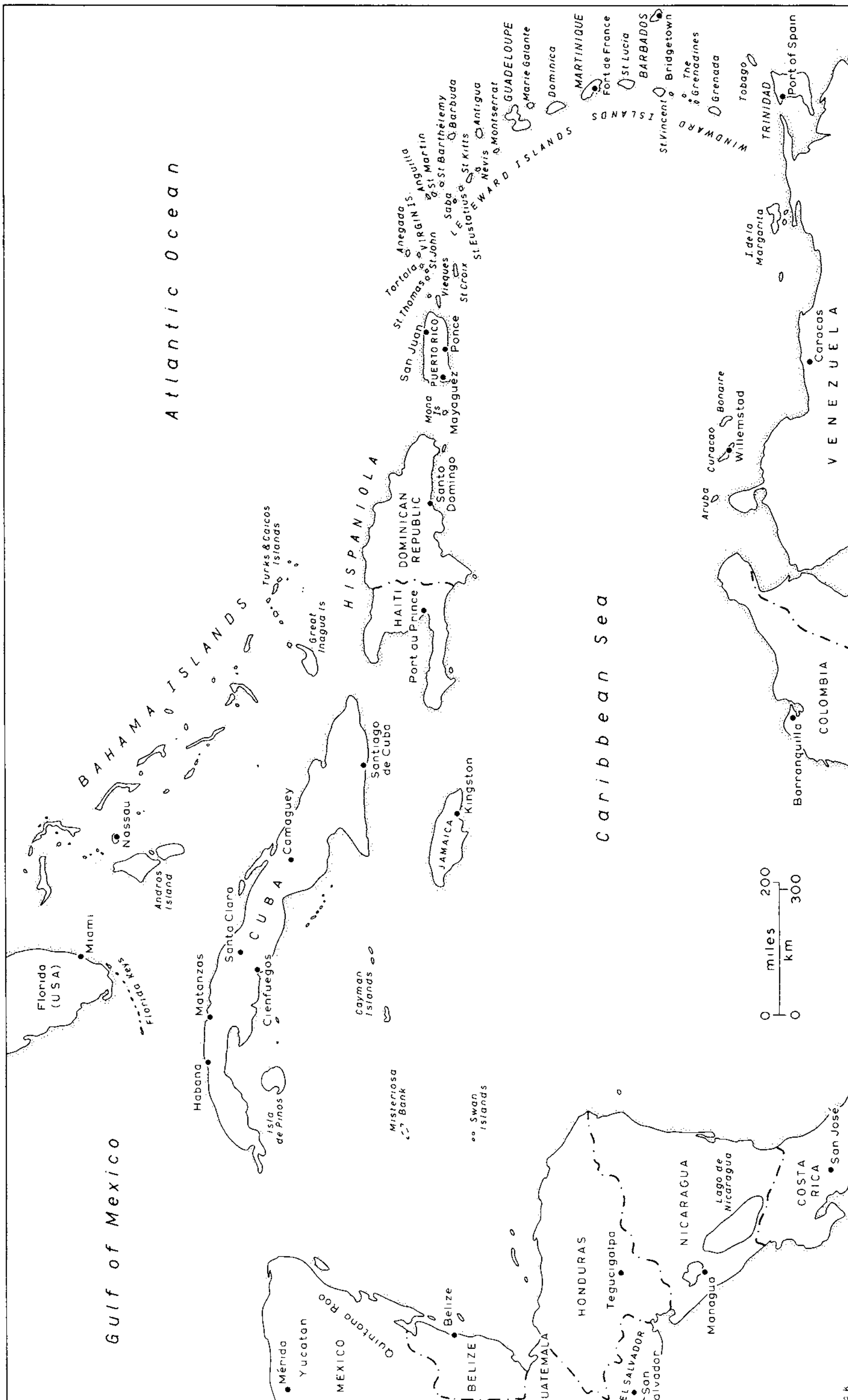

Fig. 1.1 The West Indies: a locational map

forested land of Jamaica and Puerto Rico, to the chain of the Lesser Antilles and Trinidad, and even the drier islands north of the Venezuelan coast.

Today, on first arrival in the West Indies, the modern traveller still perceives the landscape as bearing the imprint of a bounteous serendipity, although to some extent the senses deceive, both the environment, and its plant and animal components, having been sadly degraded in the intervening years. Indeed, the region is now listed as one of those which has undergone major species loss in historic times (Westermann, 1953). Social scientists often characterise these islands as having been shaped by two of the most severe human traumas of global significance to have taken place within the last four centuries: first, the virtually total and rapid removal of a large aboriginal population following initial European contact; and, later, the forced transference into them of many hundreds of thousands of Africans from their homelands under conditions of slavery to support a system of plantation agriculture. The environmental degeneration inferred above, which thus far has not been detailed in print, may be deemed to form a third trauma, which is perhaps now of equal and growing importance to the inhabitants. It is the interaction between, and ramifications of these three major considerations which have moulded much of West Indian history and geography, and which form the main themes for discussion in this book.

Clearly, an objective assessment of the nature of such a potentially munificent environment, and of the ways it can change over time, is essential to any geographical interpretation of the consequences of human occupancy, in its several distinctive cultural threads, within the region; and it is with this in mind that its salient characteristics are evaluated below.

Geology and surface features

The West Indies islands lie largely within the tropics along a broad arc from the western tip of Cuba to the southeasternmost extremity of Trinidad, a considerable distance of some 4,000 km (Fig. 1.1), and they display a great diversity not only of size (Table 1.1) but also of landforms, geology and relief. Much of the region is tectonically unstable, subject to earthquakes, and to geothermal and volcanic activity. Indications of small-scale geothermicity are present today in many of the smaller volcanic islands of the Lesser Antilles in the form of steam vents (termed locally *fumaroles* or *soufrières*), which often give rise to a surface scattering of sulphur deposits. Larger-scale volcanic activity has occurred from time to time, one of the best-known recent examples being the eruption of Mont Pelée in Martinique in 1902, ash and lava from which engulfed most of the adjacent town of St Pierre, killing over 30,000 of its inhabitants (Plate 1.1). The 1976 instability of Mont Soufrière in Guadeloupe, and the 1979 eruption of Mount Soufriere in St Vincent are considered by some geologists to herald

Table 1.1 *Groupings and size of islands in the West Indies, their maximum elevation, and their major component rock types*

Island group	Island	Size (km^2)	Max. elevation (m)	Major rock type
Greater Antilles (88% land area)	Cuba	110,922	1,972	L/S/M
	Jamaica	11,424	2,257	L/S/M
	Española	76,484	3,175	L/S/M
	Puerto Rico	8,897	1,065	L/S/M
	Cayman Islands	241	15	L
Bahamas (5% land area)	Bahamas	11,826	*c* 100	L
Lesser Antilles (3% land area)	US Virgins			
	(St Croix			
	St Thomas			
	St John)	344	465	S/M/V
	British Virgins	174	518	S/M/V
	St Martin	34	424	L
	St Eustatius	21	549	V
	Saba	13	884	V
	St Kitts	176	1,156	V
	Nevis	130	985	V
	Anguilla	88	55	L
	Antigua	280	403	L/V
	Barbuda	161	22	L
	Montserrat	84	742	V
	Guadeloupe	1,702	1,467	V/L
	Martinique	1,090	1,397	V
	Barbados	440	338	L/S+
	Dominica	790	1,422	V
	St Lucia	603	951	V
	St Vincent	389	1,179	V
	Grenada	345	840	V
Trinidad & Tobago (2% land area)	Trinidad	4,828	941	L/S/M
	Tobago	300	572	M/V
Islands north of Venezuelan coast (1% land area)	Bonaire	288	241	L/V
	Curacao	443	193	L/V
	Aruba	190	167	S/V/L
	Margarita	1,150	920	M/V

The smallest islands have not been included in this list

Key to rock types: L – limestones (usually Tertiary or Pleistocene)
M – metamorphic; S – sedimentary; V – volcanic
+Barbados has a similar structural base to Trinidad & Tobago (see p. 12)

another phase of vulcanity which so far (1989) however has not materialised in any major way. The existence of crater lakes close to the summit peaks of many volcanic islands confirms the vigour of eruptive forces in the past; and some of these, such as one in St Vincent dated by radiocarbon techniques to about 14,000 years before present (Morley, 1972), have been so great that entire islands were covered with a thick layer of ash, which must have destroyed all local plant and animal life forms there. While volcanic activity is absent from the Greater Antilles, earthquakes have been relatively frequent there, and some of them have been very severe, such as that which destroyed Port Royal in Jamaica in 1692, and the major earth movement in the same island in 1907. Only in the Bahamas are signs of major recent tectonic instability lacking.

All these features have resulted from sub-crustal pressures, which cause continents to move relative to each other over long periods of time. Such movements are concentrated on tectonic plates which may vary in size. Pressures on the Caribbean plate, an area which roughly coincides with that of the present Caribbean Sea, and the outer edges of which conform approximately to the arc of the Lesser Antilles, have been induced by the northward movement of South America relative to North America since Cretaceous times (Table 1.2); and it was in the Cretaceous period, some 135 million years ago, that the Caribbean Sea first became clearly differentiated (Freeland & Dietz, 1971, 1972; Malfait & Dinkelmann, 1972; Mattson, 1972). During the Late Cretaceous, a chain of small, scattered volcanic islands was created in the north of the region, including the core formation of present-day Jamaica, Española, Puerto Rico and southeastern Cuba: and these have been termed the proto-Antilles. Later, probably between the Middle Eocene and the Middle Miocene, some of these areas were again submerged, encouraging a massive submarine deposition of sandstones and limestones, at least some of which subsequently were altered by heat or pressure associated with batholithic intrusions. These latter in turn gave rise to localised reefs of precious metals, such as those bearing gold which are located in the Yaqui district of northern Española (Chapter 3). During the late Miocene and Pliocene periods, the submergence was reversed, so that the four major islands of the Greater Antilles (Cuba, Jamaica, Española, Puerto Rico) began to assume their present size and form; and at the same time, many more islands were uplifted above sea level, particularly those along the Aves submarine ridge which marks the eastern edge of the Caribbean plate, along which the present Lesser Antilles were built.

The Pliocene, a period in which temperatures everywhere gradually were reduced from the world-wide warmth of much of the Miocene, was followed by the clearly fluctuating warm and cold phases of the mid- and high-latitude Pleistocene 'Ice Ages', in which the physical environments of

Table 1.2 *The major geological periods which relate to the formation of the West Indies*

Geological period	Epoch and approximate age, million years
Quaternary	Pleistocene
	3.0
	Pliocene
	10.0
	Miocene
	27.0
	Oligocene
	38.0
	Eocene
	54.0
	Palaeocene
	65.0
Cretaceous	Upper

the West Indies and their adjacent seas also were repeatedly and considerably transformed. Some of the most compelling evidence for this has been compiled by C. Emiliani (1971), T. Van der Hammen (1974) and K. S. Brown (1982), who suggest that, in the higher-latitude glacial phases of this period, climates in tropical America underwent a general aridification and cooling. Associated with the cooling was a much stronger northerly component in windflow patterns than is the case at present, especially in the north of the region (Gates, 1976); in the south, temperatures would have been kept relatively high by the maintenance of the strong Guyana ocean current (Brown, 1982). Emiliani has proposed that the degree of cooling at maximum would have been of the order of 6° C, in terms of mean annual lowland temperatures; and Brown has raised this figure to 9° C. Cool phases would have been characterised further by a lowering of sea level, as increasingly greater and greater amounts of surface and atmospheric moisture came to be locked into the ice sheets of high latitudes; indeed, sea levels may have been as much as 120 m below the present datum at the maximum of the last, Wisconsin glaciation, some 15,000 to 19,000 years ago. Clearly, in turn this would have resulted in a much greater extension of land area in particular parts of the Caribbean, notably in the Bahamas, where a land mass equivalent to the size of present-day Florida emerged (Campbell, 1978); and in a greater vertical differentiation of relief above sea level everywhere. Following the maximum of the Wisconsin glaciation, sea levels have risen at a rate of at least 10 m per 1,000 years until 7,000 years ago, and then more slowly to a peak of *c* 3 to 5 m *above* the present datum 5,000 years ago (Brown, 1982), since when they have fallen slowly again. One further additional point concerning sea level changes is that in long-past, *pre*-Wisconsin interglacial phases, sea levels are known to have risen to heights of up to 100 m above the present datum, and this would have been sufficient to give rise to the virtual disappearance below oceanic waters of most of the Bahama group, as well as other low-lying land in the region, and of course significantly reduce the vertical differentiation of relief everywhere.

One other notable consequence of the warm, interglacial phases of the Pleistocene period was that particularly favourable conditions arose for the growth of reef coral. Full details of this have been elucidated for Barbados (Matthews, 1973; Mesolella, Sealy & Matthews, 1970; Mesolella, Matthews, Broecker & Thurber, 1969; Senn, 1946), the Bahamas, Jamaica (Goreau, 1959) and the islands north of the Venezuelan coast (Alexander, 1961). In Barbados, the interaction between gradual tectonic uplift, the building of reef tracts in successive warm phases of the Pleistocene, and the erosive effects of changing sea levels, has resulted in the development of a terraced coral cap (Plate 1.2), each terrace representing the remains of a now elevated, former reef tract. Mesolella *et al.* (1969) have estimated that the development of the coral cap in Barbados, which at maximum is over 100 m in thickness, took between 0.55 and 1 million years. Further consequences of Pleistocene climatic rhythms may be seen, both in Barbados and elsewhere, in the existence of water-eroded but presently dry valleys which cross reef terraces. It has been suggested, both by J. Tricart (1968) and J. Fermor (1972), that these originated during phases in which sea level was lower than at present, when annual rainfall totals were somewhat greater, at least at higher altitudes, due to the increased orographic effect. Pleistocene climatic rhythms also affected the patterns of plant and animal distribution within the region, a point which is to be further discussed later in this chapter.

In respect of their geological base and structure, and their surface appearance, West Indies islands may be categorised into four groups, as displayed in Fig. 1.2. The *first* of these consists of the Greater Antilles

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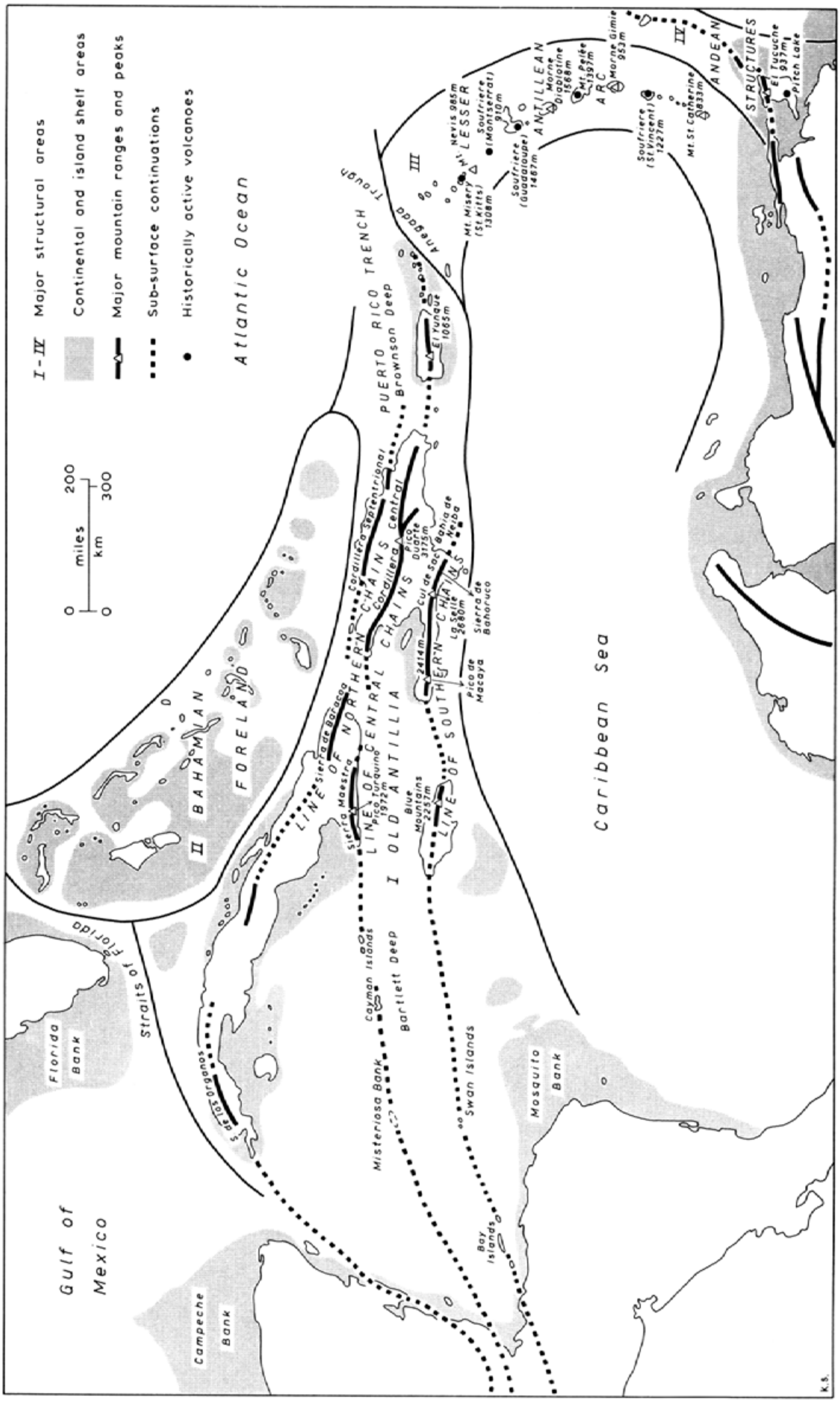

Fig. 1.2 Major structural divisions of the West Indies

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(Cuba, Española, Jamaica and Puerto Rico), their offshore islands, the Cayman, Bay and Swan islands, and the Misteriosa Bank. Together, this forms an 'old' geological sub-region which has been termed 'Old Antillia', reflecting its relatively early uplift above sea level, at least in its core districts. Its eastern structural boundary lies to the east of the Virgin Islands, along a major fault trough known as the Anegada Trench, the floor of which lies some 4,500 m below sea-level; and the zones of folding and faulting within the sub-region as a whole are distinctive, connecting with similar features in the west in Yucatan, other parts of Mexico, and northern Central America. Three discontinuous chains of mountains are present in this sub-region, and these may conveniently be described as the southern, central and northern chains, even though their precise boundaries relative to each other are not always clear. The southern chain extends westward from the Sierra de Bahoruco in the extreme south of Española to the rugged southern peninsula of Haiti, surfaces again in the crystallines of the Blue Mountains of Jamaica, rises above the Caribbean Sea in the Swan and Bay islands, and then further to the west forms a series of low east-west-trending ranges in Honduras and northern Nicaragua, before terminating in southern Mexico's Sierra de Chiapas. North of this chain is a major fault depression, which is traceable from the Bahia de Neiba in southern Española, through the Cul de Sac plain of Haiti, the Bartlett Deep (the floor of which attains a depth of 7,250 m only 30 km south of the Cuban coast), and the Montagua valley of central Guatemala to the Valley of Chiapas. The central chain runs from the western Virgin Islands, through the central mountains of Puerto Rico, the Cordillera Central of Española, the Sierra Maestra of Cuba, and thence to the Cayman Islands, the Misteriosa Bank, the Sierra de los Chumantanes of central Guatemala, and the Sierra de San Cristobal in Chiapas. Faulted depressions, filled with relatively recent sediments, lie to the north of this central chain, although these are never as pronounced nor as continuously visible as those lying to the north of the southern chain: they are best defined in the Puerto Rico trench, the Yaqui del Norte of Española (Plate 1.3), and in Cuba. In comparison with the southern and central chains, the northern chain is a much lower and less continuous feature, reaching maximum altitudes slightly in excess of 1,300 m both in Cuba and Española; its most conspicuous expression is to be found in the Cordillera Septentrional of the northern coast of Española, and in the Sierra de Baracoa and the Sierra de los Organos of Cuba, the latter having some strikingly eroded karst features. North of this northern chain lies a further, deep down-faulted trough, which extends to 8,540 m below sea level within the Puerto Rico trench.

Surface features in Old Antillia tend to be exceptionally diverse. Small down-faulted and alluvial plains intermingle with the rugged mountain chains, many of which reach considerable heights. The underlying geology

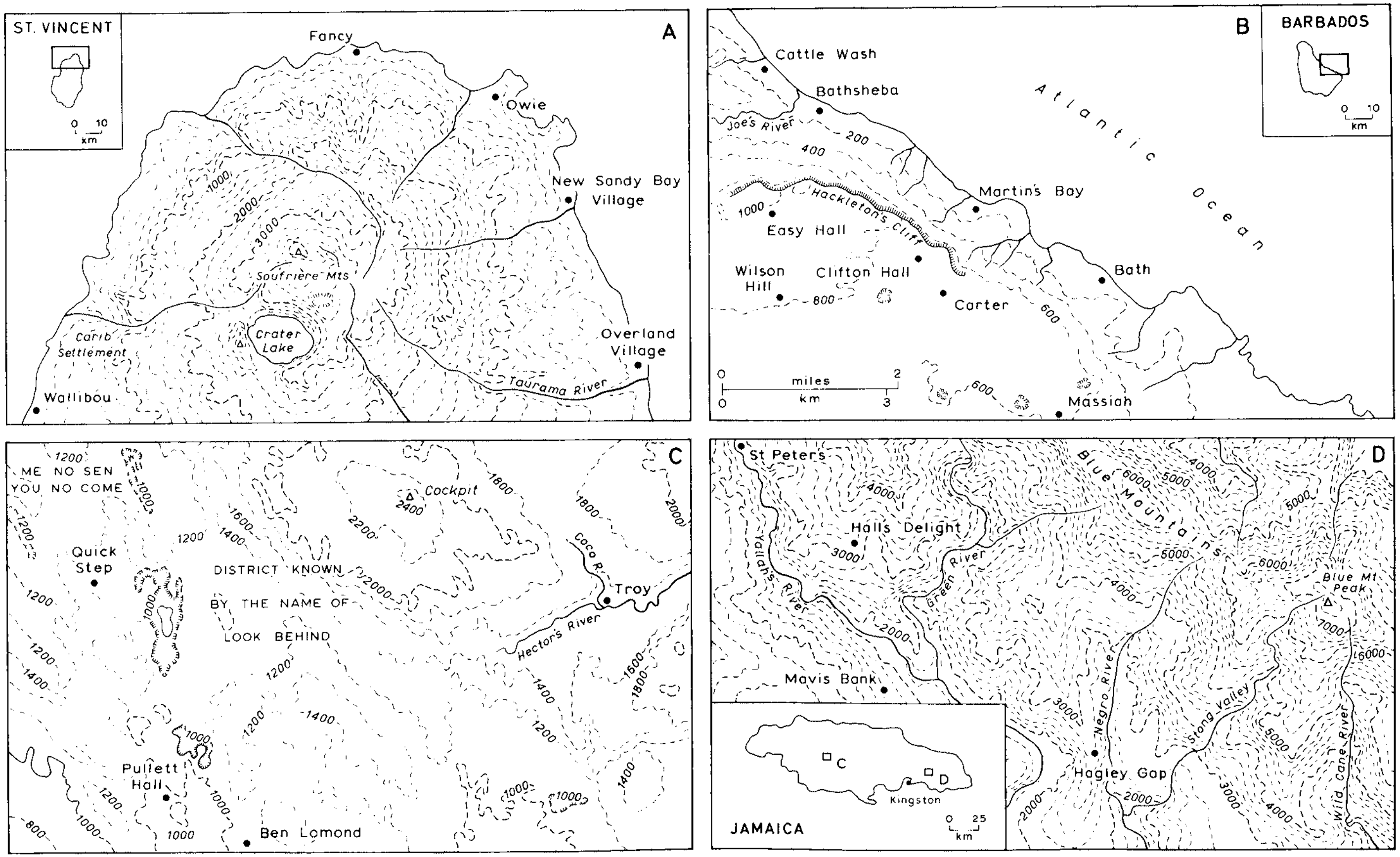

Fig. 1.3 West Indies' landforms. (a) volcanic landforms, northern St Vincent; (b) Barbados, showing the coral limestone cap and the Scotland District core; (c) Tertiary limestone landforms, Jamaica; (d) landforms on crystalline rocks, Blue Mountains, Jamaica. Heights in feet. Reproduced, with permission, from maps produced by the Department of Overseas Surveys, England.